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Identification and Significance of Innovation

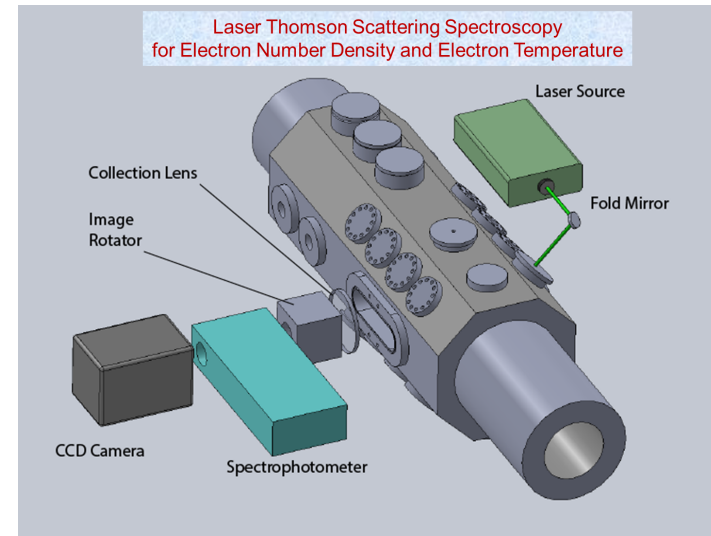
Planetary entry involves very high velocities and a significant source of vehicle heating is the radiation from the bow shock-heated plasmas formed in front of the vehicle. The EAST facility has the capability of producing a shockwave in different gas mixtures at very high speeds and at conditions that are typical of planetary entries. The primary diagnostic in this facility is emission spectroscopy to measure shock radiance spectra. Critical to the understanding of the spatiotemporal nature of shock radiance spectra is the need to determine the shock front arrival time to great precision. To address this, two imaging diagnostics are proposed – one that implements the technique of Rayleigh and Thomson scattering using MHz rate pulse burst laser in conjunction with a MHz rate high speed camera, and another a laser-schlieren system using a CW laser system. To understand the post-shock nonequilibrium dynamics, a laser Thomson scattering system is proposed to measure electron number density with high spatial and temporal resolution.

Estimated TRL at beginning and end of contract: (Begin: 2 End: 4)

Technical Objectives and Work Plan

The technical objectives of this effort are to detect the shock front arrival and measure shock speeds to a very high precision; and to measure electron density with high spatial and temporal resolution in an environment that is comparable to the post-shock conditions in the EAST facility. To qualify as a measurement tool for the EAST facility, the following work plan needs to be executed:

1. Build an apparatus for traveling shockwaves with sufficient strength at very low-pressure conditions.
2. Demonstrate detection of shock front edge arrival and measurement of shock velocity with high accuracy with both Laser scattering and Laser-schlieren methods in the shockwave generator apparatus for conditions relevant to the EAST facility.
3. Quantify signal-to-noise ratio (SNR) and measurement accuracy for EAST facility post-shock conditions for shock detection and velocity, and verify if detection exceeds the accuracy goal of 0.1 microseconds.
4. Demonstrate multiple laser Thomson scattering schemes to measure electron number density and electron temperature with high spatial and temporal resolution.
5. Quantify signal-to-noise ratio of the laser Thomson scattering diagnostic and detection limits of electron number density and electron temperature.



NASA Applications

The proposed diagnostics will support the development of spacecraft for entering planetary atmospheres. These tools will provide electron number density and electron temperature thus yielding key insight into radiative properties of the plasma formed post-bow shock and help improve the fidelity of current measurement techniques. Information thus obtained should aid in the design of advanced spacecraft and help improve simulation tools used in the design of thermal protection systems (TPS), thereby enabling reduction in their design margins.

Non-NASA Applications

The ability to accurately measure shock location, shock velocity, and electron number density would be attractive to research on hypersonic vehicles, and should find use in defense facilities employed in the development of high speed missiles and aircraft. Other potential benefit would be to the development of Hall thrusters, which have a need for accurate, time-resolved electron number densities.

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